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(54) A bidirectional optical transmission system having a light-interruption detecting function.

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(73) Proprietor: **FUJITSU LIMITED**
1015, Kamikodanaka,
Nakahara-ku
Kawasaki-shi, Kanagawa 211 (JP)

(72) Inventor: **Shimizu, Kazuyoshi LM Yoshinocho Minami 503**
1-22-5, Mutsumi-cho
Minami-ku
Yokohama-shi Kanagawa 232 (JP)

(74) Representative: **Lehn, Werner, Dipl.-Ing. et al**
Hoffmann, Eitle & Partner,
Patentanwälte,
Postfach 81 04 20
D-81904 München (DE)

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Jouve, 18, rue Saint-Denis, 75001 PARIS

Description

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a bidirectional optical transmission system having a light-interruption detecting function.

In a bidirectional optical transmission system, it is required to be able to surely detect a light-interruption state of an optical signal at a receiving party, caused by a cutting or deterioration of an optical transmission line made of an optical fiber, or caused by a malfunction in a transmitting office.

(2) Description of the Related Art

Cross references relating to the present invention are as follows.

(a) Japanese Unexamined Patent Publication No. 59-17637 published on October 6, 1984, which discloses modulating a supervising signal having a single frequency common to all repeaters and different from that of an information-containing light signal, transmitting the signal through a transmission line, receiving it at a terminal unit, separating the information light signal and the supervising light signal, and detecting a fault by monitoring the level of the supervising light signal.

(b) Japanese Unexamined Patent Publication No. 60-144031 published on July 30, 1985, which discloses constant supervision of the characteristics of a transmitter in a bidirectional optical transmission system. At a receiver, a signal from the transmitter in the same office is fed back to the receiver part, and a signal transmitted through an optical fiber is simultaneously input into a light receiving element with the light signal configuration, and a converted electrical signal is separated. Thus, the light output signal from the transmitter part associated with the receiver is constantly supervised.

(c) Japanese Unexamined Patent Publication No. 60-144032 published on July 30, 1985, which discloses demodulation of high-speed pulses into a baseband signal by the use of a pulse modulating method, and passing the baseband signal through a switch, or directly passing the high speed pulse signal through a logical switch.

(d) Japanese Unexamined Patent Publication No. 53-110315 published on September 27, 1979, which discloses a repeater including a supervising pilot signal oscillator.

(e) Japanese Unexamined Patent Publication No. 55-136737 published on October 24, 1980, which discloses a single-frequency supervising pilot signal for supervising all repeaters.

(f) Japanese Unexamined Patent Publication No. 55-136737 published on October 24, 1980, which discloses deteriorated LD information and other information related to the level of received light, which are converted into frequency information and sent to a supervising office for detection of a light repeater in which the LD is deteriorated.

(g) Japanese Unexamined Patent Publication No. 62-245827 published on October 27, 1987, which discloses a fault supervising system in which when a fault occurs, the fault position and the fault contents are simultaneously informed to a terminal without taking the transmission line off line.

In an optical transmission, a bidirectional optical transmission system utilizing a wavelength-division multiplexing module or a photo coupler has been considered and developed to attain effective utilization of optical fibers.

Such a wavelength-division multiplexing module or a photo coupler in one office is used to pass a signal transmitted from the one office through a common optical fiber to another office, and also to pass a signal received from the other office through the same common optical fiber to the first office. Thus, only a single optical fiber is used for the bidirectional optical transmission.

The wavelength-division multiplexing module or the photo coupler, however, has a crosstalk characteristic as later decribed in more detail. Due to the crosstalk in the wavelength-division multiplexing module or the photo coupler, even if a light interruption state occurs in the receiving office or on the optical fiber, it is conventionally difficult to determine whether the signal being received is from the other office or from the same office having leaked through the module or photo coupler into the received part from the transmitter.

None of the above described cross references disclose the problem of crosstalk in the wavelength-division multiplexing module or the photo coupler.

A known bidirectional optical transmission system (AU-B-45 168) comprises two offices each of which has light-transmitting means for generating a transmission signal to be transmitted from a first office to a second office and receiving means for receiving a signal transmitted from another office. The light-transmitting means comprises auxiliary transmitting means which generates an optical fiber link monitoring signal which is converted into an optical signal separately from the transmission signal.

Another known optical transmission system (DE-A-36 32 047) includes a multiplexer producing an information signal which is converted to an optical signal having a selected wave length. A plurality of optical information signals is supplied to a transmission line via a wave length multiplexer.

SUMMARY OF THE INVENTION

The object of the present invention is to enable sure detection of a light-interruption state of a receiving office even when the received signal includes cross-talk from the transmitting circuit in the transmitting office.

This object is satisfied by a bidirectional optical transmission system according to claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

Figure 1 is a block diagram showing an example of a conventional bidirectional optical data transmission system;

Fig. 2 is a principal block diagram showing a basic construction of a bidirectional optical data transmission system according to an embodiment of the present invention;

Fig. 3 is a block diagram showing a practical construction of the bidirectional optical data transmission system accorcing to an embodiment of the present invention;

Fig. 4 is a circuit diagram showing an example of a light transmitting circuit and a light-interruption detecting signal generating circuit in a biderectional optical transmitting system according to an embodimemt of the present invention;

Fig. 5 is a circuit diagram showing another example of a light transmitting circuit and a light-interruption detecting signal generating circuit in a bidirectional optical transmitting system according to an embodimemt of the present invention;

Fig. 6 is a block diagram showing an example of the light receiving circuit in Fig. 2;

Fig. 7 is a waveform diagram showing an example of the output waveform from the light transmitting circuit; and

Fig. 8 is a frequency band diagram showing the frequencies of the signals to be superimposed on the transmitted signals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For better understanding of the present invention, a conventional bidirectional optical transmission system will first be described with reference to Fig. 1.

In Fig. 1, an office 1 and an office 2 are connected by an optical fiber 3. Through the optical fiber 3, an upward channel and a downward channel are established.

The office 1 includes a light transmitting part (LTR) 16, a light receiving part (LRV)17, a photo coupler or in other words an optical directional coupler 13, and the like. The photo coupler 13 passes the output signal from the light transmitting part 16 to the optical fiber 3, and also branches the optical signal received through the optical fiber 3 from the office 2 to the light receiving part 17.

The office 2 also includes a light transmitting part (LTR) 26, a light receiving part (LRV)27, an optical coupler 23 and the like having similar functions to those in the office 1.

When the bidirectional optical transmission system is a wavelength-division multiplexing system, multiwave-division multiplexing modules are used instead of the photo couplers 13 and 23.

In the optical data transmission system, the transmitted light output from the light transmitting part 16 in the office 1 is received through the photo coupler 13, the optical fiber 3, and the photo coupler 23 by the light receiving part 27 in the office 2. Similarly, the transmitted light output from the light transmitting part 26 in the office 2 is received through the photo coupler 23, the optical fiber 3, and the photocoupler 13 by the light receiving part 17 in the office 1.

In such a bidirectional data transmission system, a light-interruption detecting circuit is required which can surely detect the generation of a fault when the optical signal from one office is interrupted due to a fault such as cutting or a deterioration of the optical fiber 3, or malfunction of the transmitting part.

In a conventional light-interruption detecting circuit, the interrupted state of the signal at the receiving office is detected by the method of detecting a signal component in a digital signal, or by the method of detecting the amount of signal in a closed eye pattern.

In a circuit element such as a photo coupler or a wavelength-division multiplexing module used in a wavelength multiplexing system in a bidirectional optical data transmission system, crosstalk is often generated.

For example, as shown by a dotted line in the photo coupler shown in Fig. 1, the light output from the light transmitting part 16 leaks within the photo coupler 13 to the light receiving part 17 side, as well as being sent to the optical fiber 3.

On the other hand, in the case of a bidirectional transmission or wavelength-division multiplexing transmission, the signal configurations such as coding rules are often the same between the optical signal transmitted from the office 1 and the optical signal transmitted from the office 2. Therefore, it is difficult for the light receiving parts 17 and 27 to discriminate whether the received signal is from the other office through the optical fiber or from the same office having leaked in the photo coupler into the receiving part.

As a result, if there is crosstalk in the transmitting

office, that crosstalk is detected as an optical signal even if the optical signal from the other office is interrupted so that the light-interruption state of the other office cannot be detected.

To clearly discriminate the crosstalk signal from the real receiving signal from the office 2, the level of the crosstalk signal should be lower than - 70 dB if the power of the signal transmitted from the transmitting part 26 is -3 dB. However, the crosstalk signal passing through the photo coupler 13 is actually for example as large as -30 dB. Even when a wavelength-division multiplexing module is used, the level of the crosstalk signal is -60 dB which is too large for clearly discriminating the signal actually being received from the crosstalk signal.

As a countermeasure to this, it may be sufficient to use a photo coupler or a wavelength-division multiplexing module which is designed not to generate crosstalk. Such a photo coupler or a wavelength-division multiplexing module, however, is too expensive so that it is disadvantageous for realizing a low cost system. It may also be possible to intentionally deteriorate the minimum received light level in the light receiving part so as not to detect a signal of the crosstalk level. This, however, results in the light receiving part not sufficiently using its performance capability.

Accordingly, an object of the present invention is to enable sure detection of the light-interruption state at a receiving office even when the signal being received includes crosstalk from the transmitting circuit in the same office.

An embodiment of the present invention will be described in the following.

Figure 2 is a principal block diagram showing a bidirectional optical transmission system according to an embodiment of the present invention.

In Fig. 2, a bidirectional optical transmission system having a light-interruption detecting function is shown as a block diagram. The bidirectional optical transmission system effects bidirectional optical transmission between offices 10 and 20 through an upward channel and a downward channel by utilizing a common optical transmission line 30. The office 10 includes a light transmitting part 160, a light receiving part 170, and a light passing unit 130. The light transmitting part 160 generates a transmission signal having a high level and a low level to be transmitted from the transmitting office 10 through the light passing unit 130, and the upward channel of the common optical transmission line 30 to another office 20. The light receiving part 170 receives a receiving signal from the office 20 through the downward channel to the first office 10. The light passing unit 130 passes the transmission signal from the light transmitting circuit 160 to the upward channel, and also passes the receiving signal from the downward channel to the light receiving part 170.

The office 20 also includes a light transmitting part 260, a light receiving part 270, and a light passing unit 230 having functions similar to those in the office 10.

The light transmitting part 160 includes a transmitting circuit 161 and a light-interruption detecting signal superimposing circuit 162 for superimposing a light-interruption detecting signal on the transmission signal. The light transmitting part 260 also includes a transmitting circuit 261 and a light-interruption detecting signal superimposing circuit 262 for superimposing a light-interruption detecting signal on the transmission signal. The frequency of the light-interruption detecting signal output from the light-interruption detecting signal superimposing circuit 161 is different from the frequency of the light-interruption detecting signal output from the light-interruption detecting signal superimposing circuit 261. The light receiving part 170 includes a receiving circuit 171 and a light-interruption detecting signal detecting circuit 172. The light-interruption detecting signal detecting circuit 172 detects the light-interruption detecting signal from the office 20 by identifying the frequency of the light-interruption detecting signal output from the office 20.

For example, when a transmission is effected from the transmitting circuit 161 to the receiving circuit 271, the light-interruption detecting signal having the frequency f_1 is superimposed on the transmitted signal by the light-interruption detecting signal superimposing circuit 162. At the the receiving circuit 271 side, whether or not the light-interruption detecting signal f_1 is present is detected by the light-interruption detecting signal detecting circuit 272 to determine the light-interruption state of the transmission signal from the transmitting circuit 161. At this time, there is also a signal leaked from the transmitting circuit 261 to the receiving circuit 271. However, since the frequency of the light-interruption detecting signal superimposed on the signal is f_2, the detecting circuit 272 can discriminate this from the transmitted signal from the transmitting circuit 161. Accordingly, the detection of the light-interruption state on the side of the transmitting circuit 161 is not disturbed by the leakage signal.

Figure 3 is a block diagram of a bidirectional optical transmission system according to another embodiment of the present invention. In Fig. 3, the same reference numerals as those in Fig. 2 represent the same parts. Namely, the office 10 and the office 20 are connected by the common optical transmission line 30 which in this embodiment is an optical fiber. Through the optical fiber 30, bidirectional optical transmission of an up-ward channel and a downward channel is carried out.

The office 10 includes the light transmitting circuit 161, the photo coupler 130, and the light receiving circuit 171, and further includes the light-interruption detecting signal superimposing circuit 162 which is a sine wave signal source in this embodiment for gen-

erating the light-interruption detecting signal having the frequency f_1 which is to be superimposed on the transmitted signal in the light transmitting circuit 161, and the light-interruption detecting signal detecting circuit 172 for detecting the light-interruption detecting signal having the frequency f_2 in the signal from the other office 20 and received by the light receiving circuit 171. The light-interruption detecting signal detecting circuit 172 can be constructed by a bandpass filter for passing the signal having the frequency f_2 and a detector for detecting the output signal from the bandpass filter.

The office 20 has the same construction, and includes the light-interruption detecting signal superimposing circuit 262 which in this embodiment is a sine wave signal source, the light transmitting circuit 261, the photo coupler 230, the light receiving circuit 271, and the light-interruption detecting signal detecting circuit 272. In the office 20, the sine wave signal source 262 generates a sine wave having the frequency f_2, and the light-interruption detecting signal detecting circuit 272 detects a light-interruption detecting signal having the frequency f_1 which is different from the frequency f_2. The frequencies f_1 and f_2 are selected to be outside of the band of the digital data signal.

Fig. 4 is a circuit diagram showing an example of a detailed circuit construction of the light transmitting circuit 261 and the light-interruption detecting signal superimposing circuit 262. The light transmitting circuit 161 and the light-interruption detecting signal superimposing circuit 162 have the same constructions as the circuits 261 and 262 shown in Fig. 4. In Fig. 4, 401 is a light emitting element such as an LED or the like having relatively good linear current-light output characteristics, 402 and 404 are light emitting element driving transistors for supplying modulation current to the light emitting element 401, 405 is a transmitting data signal generating circuit, and 406 is a clamp circuit. The clamp circuit 406 makes the lowest potential of the sine wave signal from the sine wave signal source 262 equal to the lower level of the power supply so that the minimum value of the sine wave current flowing through the transistor 404 is made zero.

In more detail, the sine wave signal source 262 includes an oscillator 41, a variable resistor 42, and a resistor 43 connected in series. The variable resistor 42 is used to determine the amplitude of the frequency f_2.

The transmitting signal generating circuit 405 includes a coupling capacitor 44 for passing the alternating current component of the data to be transmitted, a level determining variable resistor 45 connected between the capacitor 44 and a positive terminal V_+ of a power source, and bias resistors 46 and 47 connected in series between a negative terminal V_- of the power source.

Between the emitter of the transistor 402 and the negative terminal V_-, a bias resistor 48 and a variable resistor 49 are connected in series. The variable resistor 49 is used to determine the emitter current of the transistor 402 so as to adjust the output optical power. Between the emitter of the transistor 404 and the negative terminal V_-, a bias resistor 50 is connected.

The clamp circuit 406 includes a coupling capacitor 51 and a bias resistor 52 connected in series between the variable resistor 42 and the base of the transistor 404. The clamp circuit 406 further includes an operational amplifier 53, a diode 54 having a cathode connected to the emitter of the transistor 404 and an anode connected through a resistor 55 to an inverting input of the operational amplifier 53. Between the inverting input and the output of the operational amplifier 53, a feedback resistor 56 is connected. A resistor 57 is connected between the output of the operational amplifier 53 and the connecting point between the capacitor 51 and the resistor 52. Between a non-inverting input of the operational amplifier 53 and the negative terminal V_- of the power source, a reference voltage determining circuit including a resistor 59, a diode 60 having an anode connected to the resistor 59, and a resistor 61 connected between the cathode of the diode 60 and the negative terminal V_- of the power source. The anode of the diode 54 is connected through a resistor 62 to the positive terminal V_+ of the power source. The anode of the diode 60 is connected through a resistor 63 to the positive terminal V_+ of the power source. The potential at the anode of the diode 60 is fixed to a reference potential determined by the resistor 63, the forward voltage of the diode 60 and the resistor 61. Because of the imaginary short of the operational amplifier 53, the potential at the anode of the diode 54 is also fixed to a voltage level equal to the reference voltage.

The clamp circuit 406 functions to clamp the lowest level of the superimposed signal to the low level of the transmitted data signal.

In operation, when the potential at the emitter of the transistor 404 is lower than the reference voltage applied to the noninverting input of the operational amplifier 53, a current flows from the positive terminal V_+ through the resistor 61 , the diode 54 and the resistor 54 to increase the emitter current so as to raise the potential at the emitter of the transistor. As a result, the lowest level of the superimposed signal appearing at the collector of the transistor 404 becomes higher than the reference voltage plus the collector-emitter voltage of the transistor 404.

Whereas, when the potential at the emitter of the transistor 404 is higher than the reference voltage applied to the noninverting input of the operational amplifier 53, the diode 54 is inversely biased so that it

does not conduct.

In both cases, the operational amplifier 53 always amplifies the potential at the anode of the diode 54 by the resistance ratio of the resistors 55 and 56. The amplified voltage is applied through the resistors 57 and 52 to the base of the transistor 404. Thus, the direct current level of the voltage applied to the base of the transistor 404 is kept constant.

Since the collectors of the transistors 402 and 404 are commonly connected to the photo diode 401, the current passing through the photo diode 401 is the sum of the currents passing through the transistors 402 and 404. As a result, the sine-wave signal from the oscillator 41 is superimposed on the transmission signal (DATA).

Fig. 5 is a circuit diagram showing another example of a detailed circuit construction of the light transmitting circuit 261 and the light-interruption detecting signal superimposing circuit 262. In Fig. 5, the transmision signal (DATA) and the light-interruption detecting signal generated by an oscillator are at first synthesized by an amplifier 501 and then amplified by a transistor 502 so that the synthesized signal is output from a photo diode 503. Between the output of the amplifier 501 and the base of the transistor 502, a clamp circuit 504 is connected. The clamp circuit 504 has the same construction as the clamp circuit 406 shown in Fig. 4.

Figure 6 is a block diagram showing a detailed circuit construction of the light receiving circuit 271 and the light-interruption detecting signal detecting circuit 272. In Fig. 6, the light receiving circuit 271 includes a photo diode 601 for converting a light signal into an electrical signal, a preamplifier 602, a main amplifier 603, and a discriminating circuit 604 for discriminating the high level and the low level of the received signal. The circuit construction of the light receiving circuit 271 is the same as the conventional one. At the output of the main amplifier 603, the light-interruption detecting signal detecting circuit 272 is connected. The circuit 272 includes a band-pass filter 605 for passing only the signal having the frequency f_1, an amplifier 606, and a discriminating circuit 607 for discriminating whether or not the received signal includes the superimposed signal having the frequency f_1. The discriminating circuit 607 has the same construction as that of the discriminating circuit 604.

Fig. 7 is a diagram showing an example of the light output waveform from the light transmitting circuit 161. As shown in the figure, the sine-wave signal S as the light-interruption detecting signal and having the frequency f_1 is superimposed on the digital data signal D from the transmitting data signal generating circuit 405 for example. The lowest level of the sine-wave signal S is made not to be lower than the low level of the digital data signal D by the function of the clamp circuit 406 or 504. Therefore, even the lowest level of the sine-wave signal is superimposed in its complete form without being sliced. Acocrdingly, the signal level of the sine-wave signal is not changed at the low level or high level portion of the digital data signal. Thus, the extraction of the light-interruption detecting signal can be carried out stably.

Fig. 8 is a frequency band diagram showing an example of the frequencies f_1 and f_2 of the light-interruption detecting signals. As shown in Fig. 8, the frequencies f_1 and f_2 are selected to be out of the range of the dgital data signal to be transmitted in order for easy discrimination of the frequencies f_1 and f_2. It is preferable to select the frequencies f_1 and f_2 to be higher than the frequency of the digital data signal.

The operation of the system shown in Fig. 3 is described in the following.

For example, at the light transmitting circuit 161, the sine-wave signal having the frequency f_1 as the light-interruption detecting signal from the sine wave signal source 162 is superimposed on the transmitted signal, and the signal is then transmitted through the photo coupler 130, the optical fiber 30, and the photo coupler 230 to the light receiving circuit 271 in the office 20.

In the office 20, the light-interruption detecting signal detecting circuit 272 discriminates whether or not there is a light-interruption detecting signal f_1 in the signal received by the light receiving part 24. If the light-interruption detecting signal f_1 is not detected, the signal transmitted from the office 10 is determined to be in a light-interruption state.

On the other hand, in the office 20, a leakage signal is input from the light transmitting circuit 261 through the photo coupler 230 to the light receiving circuit 271 when the office 20 transmits a light signal to the office 10. However, since the light-interruption detecting signal superimposed on this leakage signal has the frequency f_2, the discrimination of whether or not the transmitted signal from the office 10 is interrupted is not disturbed by the leakage signal.

Various modifications are possible upon implementing the present invention. For example, in the above embodiment, an optical directional coupler is employed to realize the bidirectional optical transmission, however, the present invention is not limited to this but a wavelength multiplexing module may be employed instead of the optical directional coupler when the bidirectional optical transmission is realized by a wave-division multiplexing system. Also, it is apparent that the construction of the light transmitting circuit is not restricted to the one shown in Figs. 4 or 5 but, for example, a laser diode may be employed as a light emitting element in place of the light emitting diode (LED).

According to the present invention, even when crosstalk leaked from the transmitting circuit of the transmitting office is present in the received signal, the light-interruption state in the optical fiber or in the other office can be surely detected.

Claims

1. A bidirectional optical transmission system having a light-interruption detecting function, said bidirectional optical system effecting bidirectional optical transmission between offices (10, 20) through an upward channel and a downward channel by utilizing a common optical transmission line (30), each of said offices comprising:
light transmitting means (160 or 260) for generating a transmission signal having a high level and a low level to be transmitted from a first office through said upward channel of said common optical transmission line to another office;
light receiving means (170 or 270) for receiving a receiving signal from said other office through said downward channel to said first office; and
light passing means (130 or 230) for passing said transmission signal from said light transmitting means to said upward channel and for passing said receiving signal from said downward channel to said light receiving means;
said system being characterized by
said light transmitting means comprising light-interruption detecting signal superimposing means (162 or 262) for superimposing a light-interruption detecting signal on said transmission signal prior to converting said transmission signal into an optical signal, the frequencies of the light-interruption detecting signals from said first office and from said other office being different from each other; and
said light receiving means comprising light interruption detecting signal detecting means (172 or 272) for detecting said light-interruption detecting signal superimposed on said transmission signal from said other office by identifying said frequency of the light-interruption detecting signal from said other office.

2. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 1, wherein said signal passing means (130 or 230) is a light directional coupler.

3. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 1, wherein said bidirectional optical transmission system is a wavelength multiplexing system and said signal passing means (130 or 230) is a wavelength multiplexing module.

4. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 1, wherein said light transmitting means (160 or 260) comprises:
light amplifying means (161 or 261) for amplifying a signal to be transmitted; and
light-interruption detecting signal generating means (162 or 262) for generating said light-interruption detecting signal.

5. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 4, wherein said light amplifying means (161 or 261) comprises:
signal amplifying means (402) for amplifying a signal to be transmitted;
light-interruption detecting signal amplifying means (404) for amplifying said light-interruption detecting signal;
signal synthesizing means for synthesizing the amplified signal and the amplified light interruption detecting signal; and
electrical-optical converting means (401) for converting the synthesized signal into an optical signal;
said optical signal being sent to said light passing means (130 or 230).

6. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 5, wherein said light amplifying means (161 or 261) further comprises clamping means (406) for clamping the lowest level of said light-interruption detecting signal to the low level of said transmission signal.

7. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 6, wherein said signal amplifying means (402) is a first NPN transistor having its base connected to receive said signal to be transmitted;
said light-interruption detecting signal amplifying means (404) is a second NPN transistor having its base connected to receive said light-interruption detecting signal and having its emitter connected through an emitter bias resistor (50) to a negative terminal of a power supply;
the collectors of said first and second NPN transistors being commonly connected to said electrical-optical converting means (401).

8. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 7, wherein said clamping means (406) comprises a clamping diode (54) having its cathode connected to the emitter of said second NPN transistor (404) and having its anode connected to a point of a fixed potential, whereby when the potential at the emitter of said second NPN transistor becomes lower than a predetermined value, said clamping diode is forward biased to raise the potential of the emitter of said second NPN transistor.

9. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 8, wherein said clamping means (406) further comprises an operational amplifier (53) having a non-inverting input for applying a reference voltage, an inverting input connected through a first resistor (55) to said anode of said clamping diode (54), and an output connected through a second resistor (57 and 52) to the base of said second NPN transistor (404), the inverting input and the output of said operational amplifier being connected through a third resistor (56).

10. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 4, wherein said light amplifying means (161 or 261) comprises:

signal synthesizing means (501) for synthesizing said signal to be transmitted and said light-interruption detecting signal;

signal amplifying means (502) for amplifying the synthesized signal output from said signal synthesizing means (501); and

electrical-optical converting means (503) for converting the amplified synthesized signal into an optical signal;

said optical signal being sent to said light passing means (130 or 230).

11. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 10, further comprising a clamping means (406) for clamping the lowest level of said light-interruption detecting signal to the low level of said transmission signal.

12. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 13, wherein said signal amplifying means (502) is an NPN transistor having its base connected to the output of said signal synthesizing means (501).

13. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 12, wherein said clamping means (406) comprises a clamping diode (54) having its cathode connected to the emitter of said NPN transistor (502) and having its anode connected to a point of a fixed potential, whereby when the potential at the emitter of said NPN transistor becomes lower than a predetermined value, said clamping diode is forward biased to raise the potential of the emitter of said NPN transistor.

14. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 13, wherein said clamping means (406) further comprises an operational amplifier (53) having a non-inverting input for applying a reference voltage, an inverting input connected through a first resistor (55) to said anode of said clamping diode (54), and an output connected through a second resistor (57 and 52) to the base of said NPN transistor (502), the inverting input and the output of said operational amplifier being connected through a third resistor (56).

15. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 9 or 14 wherein said electrical-optical converting means (401) is a light emitting diode.

16. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 9 or 14, wherein said electrical-optical converting means (401) is a laser diode.

17. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 1, wherein said light receiving means (170 or 270) further comprises a light receiving circuit (171 or 271) having a photo diode (601) for converting an optical signal transmitted through said common optical transmission line (30) into an electric signal, an amplifier (602 and 603) for amplifying said electrical signal output from said photo diode (601), and a discriminating circuit (604) for discriminating the high level and the low level of the signal output from said amplifier (602 and 603).

18. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 17, wherein said light-interruption detection signal detecting means (172 or 272) comprises:

a band-pass filter (605) for passing only the signal having the frequency of said light-interruption detecting signal from said another office;

a preamplifier (606) for amplifying the signal passed through said band-pass filter; and

a discriminating circuit (607) for discriminating whether or not the signal output from said preamplifier (606) includes said light-interruption detecting signal from said other office.

19. A bidirectional optical transmission system having a light-interruption detecting function as claimed in claim 1, wherein said frequencies of said light-interruption detecting signals are higher than the frequency of said transmission signal.

Patentansprüche

1. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion, wobei das optische Zweirichtungsübertragungssystem eine optische Zweirichtungsübertragung zwischen Stationen (10, 20) durch einen Aufwärtskanal und einen Abwärtskanal unter Benutzung einer gemeinsamen optischen Übertragungsleitung (30) bewirkt, jede der Stationen umfaßt:
Lichtsendemittel (160 oder 260) zum Erzeugen eines Übertragungssignals mit einem hohen Pegel und einem niedrigen Pegel, das von einer ersten Station durch den Aufwärtskanal der gemeinsamen optischen Übertragungsleitung zu einer anderen Station zu übertragen ist;
Lichtempfangsmittel (170 oder 270) zum Empfangen eines Empfangssignals von der anderen Station durch den Abwärtskanal zu der ersten Station; und
Lichtweitergabemittel (130, 230) zum Weitergeben des Übertragungssignals von den Lichtsendemitteln zu dem Aufwärtskanal und zum Weitergeben des Empfangssignals von dem Abwärtskanal zu den Lichtempfangsmitteln;
das System ist dadurch gekennzeichnet,
daß die Lichtsendemittel Lichtunterbrechungs-Erkennungssignal-Überlagerungsmittel (162 oder 262) zum Überlagern eines Lichtunterbrechungs-Erkennungssignals auf das Übertragungssignal vor dem Umwandeln des Übertragungssignals in ein optisches Signal umfassen, wobei die Frequenzen der Lichtunterbrechungs-Erkennungssignale von der ersten Station und der zweiten Station sich voneinander unterscheiden; und
daß die Lichtempfangsmittel Lichtunterbrechungs-Erkennungssignal-Erkennungsmittel (172 oder 272) zum Feststellen des dem Übertragungssignal von der anderen Station überlagerten Lichtunterbrechungs-Erkennungssignals durch Erkennen der Frequenz des Lichtunterbrechungs-Erkennungssignals von der anderen Station.

2. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 1, wobei das Signalweitergabemittel (130 oder 230) ein Lichtrichtungskoppler ist.

3. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 1, wobei das optische Zweirichtungsübertragungssystem ein Wellenlängenmultiplexsystem ist und das Signalweitergabemittel (130, 230) ein Wellenlängenmultiplexmodul ist.

4. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 1, wobei die Lichtübertragungsmittel (160 oder 260) Lichtverstärkungsmittel (161 oder 261) zum Verstärken eines zu übertragenden Signals und
Lichtunterbrechungs-Erkennungssignal-Erzeugungsmittel (162, 262) zur Erzeugung des Lichtunterbrechungs-Erkennungssignals umfassen.

5. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 4, wobei die Lichtverstärkungsmittel (161 oder 261)
Signalverstärkungsmittel (402) zur Verstärkung eines zu übertragenden Signals,
Lichtunterbrechungs-Erkennungssignal-Verstärkungsmittel (404) zur Verstärkung des Lichtunterbrechungs-Erkennungssignals,
Signalsynthetisierungsmittel zum Zusammensetzen des verstärkten Signals und des verstärkten Lichtunterbrechungs-Erkennungssignals, und
elektro-optische Wandlermittel (401) zum Umwandeln des zusammengesetzten Signals in ein optisches Signal umfaßt,
wobei das optische Signal zu den Lichtweitergabemitteln (130, 230) gesendet wird.

6. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 5, wobei die Lichtverstärkungsmittel (161 oder 261) weiter Klemmittel (406) zum Klemmen des niedrigsten Pegels des Lichtunterbrechungs-Erkennungssignals auf den niedrigen Pegel des Übertragungssignals umfassen.

7. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 6, wobei das Signalverstärkungsmittel (402) ein erster NPN-Transistor ist, dessen Basis zum Empfangen des zu übertragenden Signals angeschlossen ist,
das Lichtunterbrechungs-Erkennungssignal-Verstärkungsmittel (404) ein zweiter NPN-Transistor ist, dessen Basis zum Empfangen des Lichtunterbrechungs-Erkennungssignals angeschlossen ist und dessen Emitter über einen Emittervorspannwiderstand (50) an einen negativen Anschluß einer Spannungsversorgung angeschlossen ist, und
die Kollektoren des ersten und zweiten NPN-Transistors gemeinsam mit den elektrooptischen Wandlermitteln (401) verbunden sind.

8. Optisches Zweirichtungs-Übertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 7, wobei die Klemmittel (406) eine

Klemmdiode (54) umfassen, deren Kathode mit dem Emitter des zweiten NPN-Transistors (404) verbunden ist und deren Anode mit einem Punkt mit festem Potential verbunden ist, wodurch, wenn das Potential am Emitter des zweiten NPN-Transistors niedriger als ein vorbestimmter Wert wird, die Klemmdiode vorwärts vorgespannt ist, um das Potential des Emitters des zweiten NPN-Transistors anzuheben.

9. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 8, wobei die Klemmittel (406) weiter einen Operationsverstärker (53) mit einem nichtinvertierenden Eingang zum Anlegen einer Referenzspannung, einen invertierenden Eingang, der über einen ersten Widerstand (55) mit der Anode der Klemmdiode (54) verbunden ist, und einen Ausgang aufweist, der über einen zweiten Widerstand (57 und 52) mit der Basis des zweiten NPN-Transistors (404) verbunden ist, wobei der invertierende Eingang und der Ausgang des Operationsverstärkers über einen dritten Widerstand (56) verbunden sind.

10. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 4, wobei die Lichtverstärkungsmittel (161 oder 261)
Signalsynthetisierungsmittel (501) zum Zusammensetzen des zu übertragenden Signals und des Lichtunterbrechungs-Erkennungssignals,
Signalverstärkungsmittel (502) zum Verstärken des von den Signalsynthetisierungsmitteln (501) ausgegebenen, zusammengesetzten Signals und
elektro-optische Wandlermittel (503) zum Umwandeln des verstärkten, zusammengesetzten Signals in ein optisches Signal umfassen,
wobei das optische Signal zu den Lichtweitergabemitteln (130 oder 230) gesendet wird.

11. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 10, das weiter Klemmittel (406) zum Klemmen des niedrigsten Pegels des Lichtunterbrechungs-Erkennungssignals auf den niedrigen Pegel des Übertragungssignals umfaßt.

12. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 13, wobei das Signalverstärkungsmittel(502) ein NPN-Transistor ist, dessen Basis mit dem Ausgang des Signalsynthetisierungsmittels (501) verbunden ist.

13. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 12, wobei das Klemmittel (406) eine Klemmdiode (54) umfaßt, deren Kathode mit dem Emitter des NPN-Transistors (502) verbunden ist und dessen Anode mit einem Punkt mit festem Potential verbunden ist, wodurch, wenn das Potential am Emitter des NPN-Transistors kleiner wird als ein vorbestimmter Wert, die Klemmdiode vorwärts vorgespannt ist, um das Potential des Emitters des zweiten NPN-Transistors anzuheben.

14. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 13, wobei das Klemmittel (406) weiter einen Operationsverstärker (53) mit einem nichtinvertierenden Eingang zum Anlegen einer Referenzspannung, einem invertierenden Eingang, der über einen ersten Widerstand mit der Anode der Klemmdiode (54) verbunden ist, und einen Ausgang umfaßt, der über einen zweiten Widerstand (57 und 52) mit der Basis des NPN-Transistors (502) verbunden ist, wobei der invertierende Eingang und der Ausgang des Operationsverstärkers über einen dritten Widerstand (56) verbunden sind.

15. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 9 oder 14, wobei das elektrooptische Wandlermittel (401) eine lichtemittierende Diode ist.

16. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 9 oder 14, wobei das elektrooptische Wandlermittel (401) eine Laserdiode ist.

17. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 1, wobei das Lichtempfangsmittel (170 oder 270) weiter einen Lichtempfangsschaltkreis (171 oder 271) mit einer Fotodiode (601) zum Umwandeln eines durch die gemeinsame optische Übertragungsleitung (30) übertragenen optischen Signals in ein elektrisches Signal, einen Verstärker (602 und 603) zum Verstärken des von der Fotodiode (106) ausgegebenen elektrischen Signals und einen Unterscheidungsschaltkreis (604) zum Unterscheiden des hohen Pegels und des niedrigen Pegels des von dem Verstärker (602 und 603) ausgegebenen Signals umfaßt.

18. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 17, wobei das Lichtunterbrechungs-Erkennungssignal Erkennungsmittel

(172 oder 272), ein Bandpaßfilter (605), das nur das Signal mit der Frequenz des Lichtunterbrechungs-Erkennungssignals von der anderen Station durchläßt, einen Vorverstärker (606) zum Verstärken des durch das Bandpaßfilter durchgelassenen Signals, und einen Unterscheidungsschaltkreis (607) zum Unterscheiden, ob das vom Vorverstärker (606) ausgegebene Signal das Lichtunterbrechungs-Erkennungssignal von der anderen Station einschließt, umfaßt.

19. Optisches Zweirichtungsübertragungssystem mit einer Lichtunterbrechungs-Erkennungsfunktion nach Anspruch 1, wobei die Frequenzen des Lichtunterbrechungs-Erkennungssignals höher sind als die Frequenz des Übertragungssignals.

Revendications

1. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière, ledit système optique bidirectionnel effectuant une transmission optique bidirectionnelle entre des bureaux (10, 20) par l'intermédiaire d'un canal montant et d'un canal descendant en utilisant une ligne (30) de transmission optique commune, chacun desdits bureaux comportant:

   un moyen de transmission de lumière (160 ou 260) pour créer un signal de transmission présentant un niveau haut et un niveau bas, à transmettre d'un premier bureau à un autre bureau par l'intermédiaire dudit canal montant de ladite ligne de transmission optique commune;

   un moyen de réception de lumière (170 ou 270) pour recevoir un signal de réception provenant dudit autre bureau, passant par ledit canal descendant vers ledit premier bureau; et

   un moyen de passage de la lumière (130 ou 230) pour faire passer ledit signal de transmission provenant dudit moyen de transmission de lumière vers ledit canal montant, et pour faire passer ledit signal de réception provenant dudit canal descendant vers ledit moyen de réception de lumière;

   ledit système étant caractérisé en ce que

   ledit moyen de transmission de lumière comporte un moyen (162 ou 262) de superposition d'un signal de détection d'une interruption de la lumière, pour superposer un signal de détection d'une interruption de la lumière audit signal de transmission avant de convertir ledit signal de transmission en un signal optique, les fréquences des signaux de détection d'une interruption de la lumière provenant dudit premier bureau et dudit autre bureau étant différentes l'une de l'autre; et

   ledit moyen de réception de lumière comporte un moyen (172 ou 272) de détection du signal amplifié de détection d'une interruption de la lumière, pour détecter ledit signal de détection d'une interruption de la lumière superposé audit signal de transmission provenant dudit autre bureau, en identifiant ladite fréquence du signal de détection d'une interruption de la lumière provenant dudit autre bureau.

2. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 1, dans lequel ledit moyen (130 ou 230) de passage du signal est un coupleur optique directionnel.

3. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 1, dans lequel ledit système de transmission optique bidirectionnelle est un système à multiplexage de la longueur d'onde, et ledit moyen (130 ou 230) de passage du signal est un module de multiplexage de la longueur d'onde.

4. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 1, dans lequel ledit moyen (160 ou 260) de transmission de lumière comporte:

   un moyen (161 ou 261) d'amplification de la lumière pour amplifier un signal à transmettre; et

   un moyen (162 ou 262) de production d'un signal de détection d'une interruption de la lumière pour produire ledit signal de détection d'une interruption de la lumière.

5. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 4, dans lequel ledit moyen d'amplification de la lumière (161 ou 261) comporte:

   un moyen d'amplification de signal (402) pour amplifier un signal à transmettre;

   un moyen (404) d'amplification du signal de détection d'une interruption de la lumière pour amplifier ledit signal de détection d'une interruption de la lumière;

   un moyen de synthèse de signal pour synthétiser le signal amplifié et le signal amplifié de détection d'une interruption de la lumière; et

   un moyen (401) de conversion électro-optique pour convertir le signal synthétisé en un signal optique;

   ledit signal optique étant envoyé audit

moyen (130 ou 230) de passage de la lumière.

6. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 5, dans lequel ledit moyen (161 ou 261) d'amplification de la lumière comporte en outre un moyen de verrouillage (406) pour verrouiller le niveau le plus bas dudit signal de détection d'une interruption de la lumière sur le niveau bas dudit signal de transmission.

7. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 6, dans lequel ledit moyen (402) d'amplification du signal est un premier transistor NPN dont la base est connectée pour recevoir ledit signal à transmettre;
ledit moyen (404) d'amplification du signal de détection d'une interruption de la lumière est un second transistor NPN dont la base est connectée pour recevoir ledit signal de détection d'une interruption de la lumière et dont l'émetteur est connecté, par l'intermédiaire d'une résistance (50) de polarisation d'émetteur, à une borne négative d'une alimentation en énergie;
les collecteurs dudit premier et dudit second transistor NPN étant connectés en commun audit moyen (401) de conversion électro-optique.

8. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 7, dans lequel ledit moyen de verrouillage (406) comporte une diode de verrouillage (54) dont la cathode est connectée à l'émetteur dudit second transistor NPN (404) et dont l'anode est connectée à un point d'un potentiel fixe, de sorte que, lorsque le potentiel de l'émetteur dudit second transistor NPN devient inférieur à une valeur prédéterminée, ladite diode de verrouillage est polarisée positivement pour élever le potentiel de l'émetteur dudit second transistor NPN.

9. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 8, dans lequel ledit moyen de verrouillage (406) comporte en outre un amplificateur opérationnel (53) présentant une entrée non inversée pour appliquer une tension de référence, une entrée inversée connectée par l'intermédiaire d'une première résistance (55) à ladite anode de ladite diode de verrouillage (54), et une sortie connectée par l'intermédiaire d'une seconde résistance (57 et 52) à la base dudit second transistor NPN (404), l'entrée inversée et la sortie dudit amplificateur opérationnel étant connectées par l'intermédiaire d'une troisième résistance (56).

10. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 4, dans lequel ledit moyen d'amplification de la lumière (161 ou 261) comporte:
un moyen (501) de synthèse de signal pour synthétiser ledit signal à transmettre et ledit signal de détection d'une interruption de la lumière;
un moyen (502) d'amplification de signal, pour amplifier le signal synthétisé fourni par ledit moyen (501) de synthèse de signal; et
un moyen (503) de conversion électro-optique pour convertir le signal synthétisé amplifié en un signal optique;
ledit signal optique étant envoyé audit moyen (130 ou 230) de passage de la lumière.

11. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 10, comportant en outre un moyen de verrouillage (406) pour verrouiller le niveau le plus bas dudit signal de détection d'une interruption de la lumière sur le niveau bas dudit signal de transmission.

12. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 13, dans lequel ledit moyen (502) d'amplification du signal est un transistor NPN dont la base est connectée à la sortie dudit moyen (501) de synthèse de signal.

13. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 12, dans lequel ledit moyen de verrouillage (406) comporte une diode de verrouillage (54) dont la cathode est connectée à l'émetteur dudit transistor NPN (502) et dont l'anode est connectée à un point à potentiel fixe de sorte que, lorsque le potentiel de l'émetteur dudit transistor NPN devient inférieur à une valeur prédéterminée, ladite diode de verrouillage est polarisée positivement pour élever le potentiel de l'émetteur dudit transistor NPN.

14. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 13, dans lequel ledit moyen de verrouillage (406) comporte en outre un amplificateur opérationnel (53) présentant une entrée non inversée pour appliquer une tension de référence, une entrée in-

versée connectée par l'intermédiaire d'une première résistance (55) à ladite anode de ladite diode de verrouillage (54), et une sortie connectée par l'intermédiaire d'une seconde résistance (57 et 52) à la base dudit transistor NPN (502), l'entrée inversée et la sortie dudit amplificateur opérationnel étant connectées par l'intermédiaire d'une troisième résistance (56).

15. Système de transmission optique bidirectionelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 9 ou 14, dans lequel ledit moyen (401) de conversion électro-optique est une diode luminescente.

16. Système de transmission optique bidirectionelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 9 ou 14, dans lequel ledit moyen (401) de conversion électro-optique est une diode laser.

17. Système de transmission optique bidirectionelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 1, dans lequel ledit moyen (170 ou 270) de réception de lumière comporte en outre un circuit (171 ou 271) de réception de lumière présentant une photodiode (601) pour convertir un signal optique transmis par l'intermédiaire de ladite ligne (30) de transmission optique commune en un signal électrique, un amplificateur (602 et 603) pour amplifier ledit signal électrique fourni par ladite photodiode (601), et un circuit discriminateur (604) pour identifier le niveau haut et le niveau bas du signal fourni par ledit amplificateur (602 et 603).

18. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 17, dans lequel ledit moyen (172 ou 272) de détection d'un signal de détection d'une interruption de la lumière comporte:

un filtre passe-bande (605) pour laisser passer uniquement le signal présentant la fréquence dudit signal de détection d'une interruption de la lumière provenant dudit autre bureau;

un préamplificateur (606) pour amplifier le signal qui est passé à travers ledit filtre passe-bande; et

un circuit discriminateur (607) pour déterminer si le signal fourni par ledit préamplificateur (606) comprend ou non ledit signal de détection d'une interruption de la lumière provenant dudit autre bureau.

19. Système de transmission optique bidirectionnelle présentant une fonction de détection d'une interruption de la lumière selon la revendication 1, dans lequel lesdites fréquences desdits signaux de détection d'une interruption de la lumière sont supérieures à la fréquence dudît signal de transmission.

Fig. 1

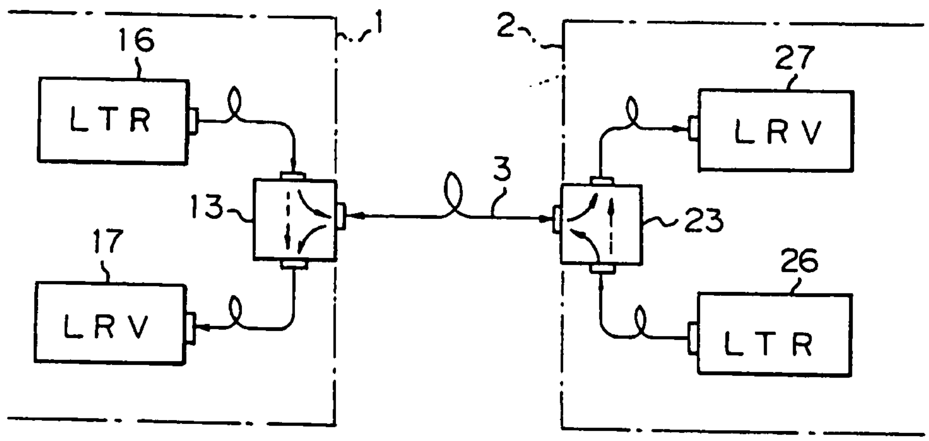
1
2
16
LTR
27
LRV
3
13
23
17
26
LRV
LTR

Fig. 2

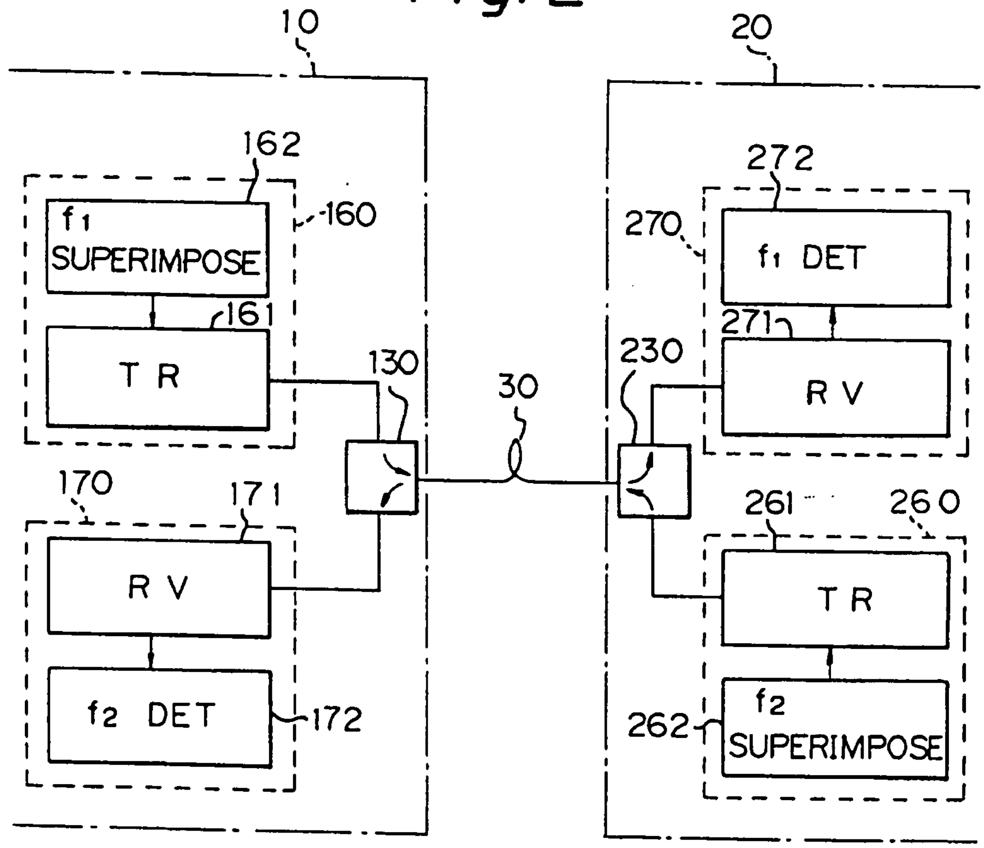
10
20
162
272
160
270
f1 SUPERIMPOSE
f1 DET
161
271
130
30
230
TR
RV
170
171
261
260
RV
TR
f2 DET
172
262
f2 SUPERIMPOSE

Fig. 3

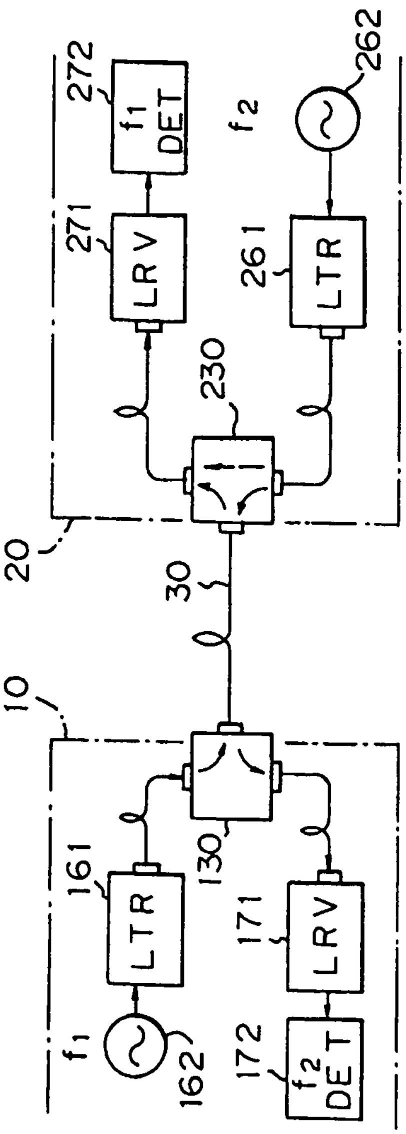
10
20
30
130
230
161
LTR
171
LRV
162
f1
172
f2 DET
271
LRV
272
f1 DET
261
LTR
262
f2

Fig. 4

261 and 262 (1st EXAMPLE)

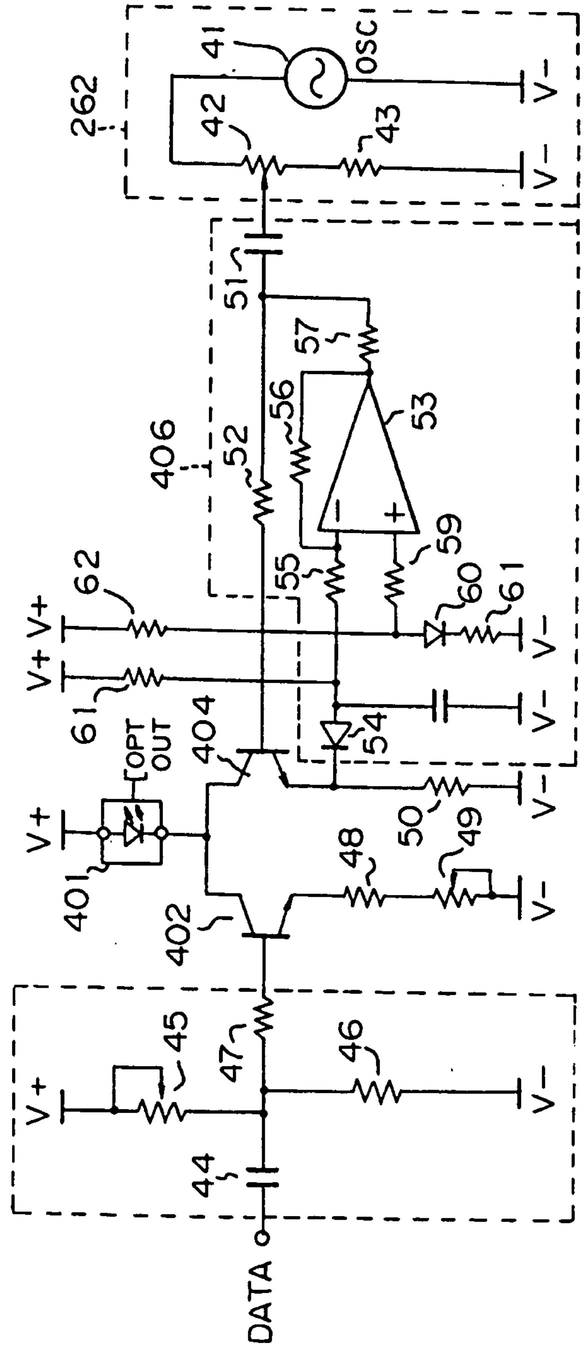

Fig. 5

261 and 262 (2nd EXAMPLE)

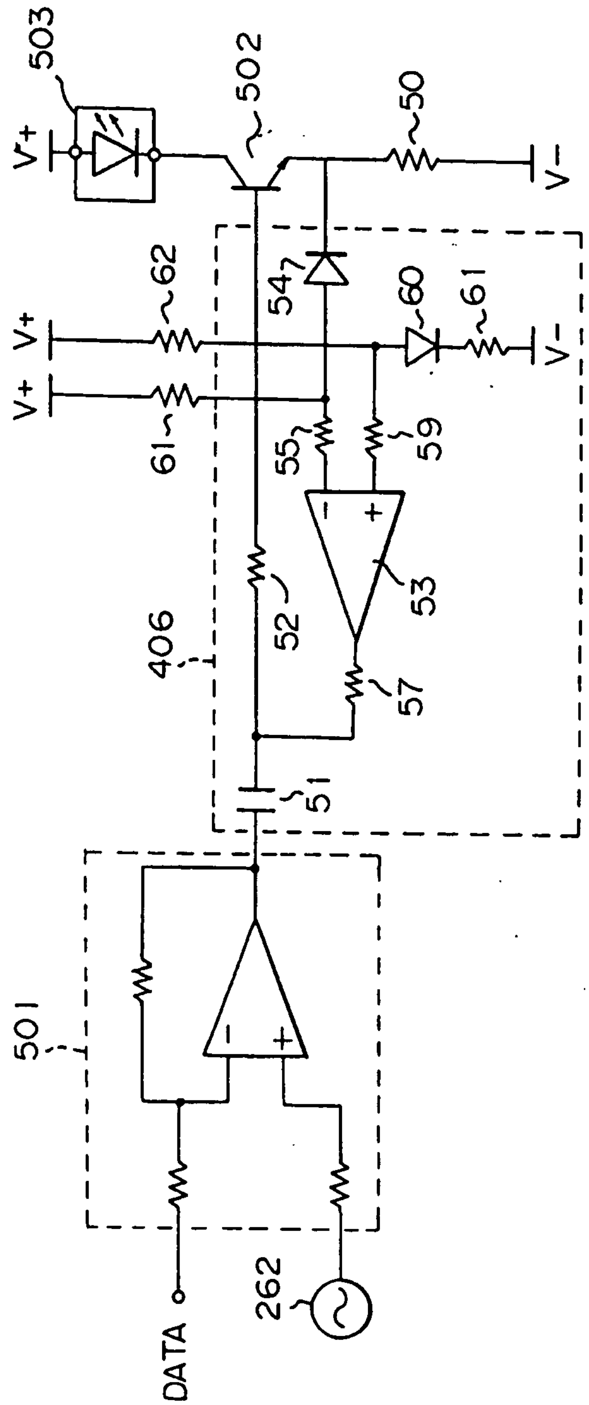

Fig. 6

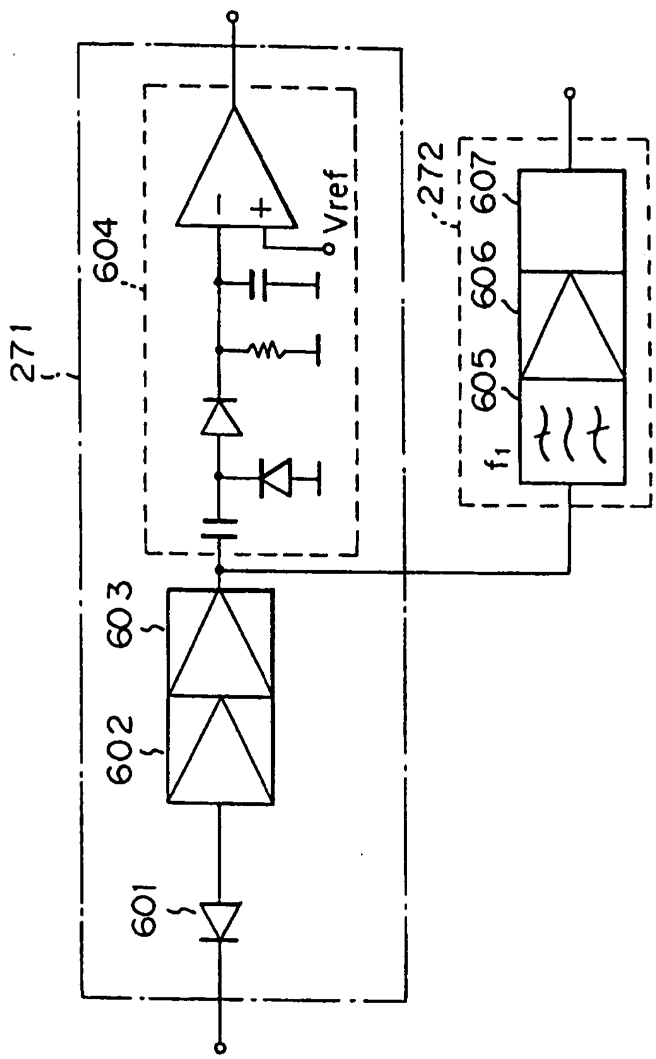

Fig. 7

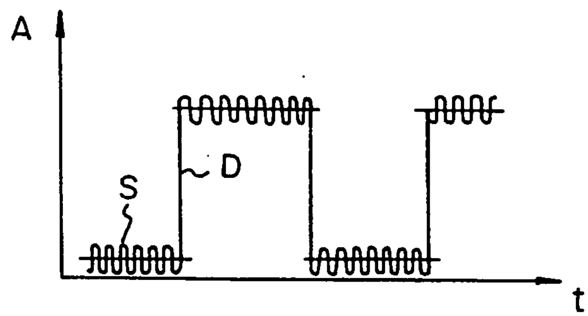

Fig. 8